J VI HIMALIA: NARROWBAND SPECTROPHOTOMETRIC SUPPORT OF A C-CLASS ASTEROID ORIGIN.

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Narrowband spectrophotometry taken in April, 1995, and July, 1996, of J VI Himalia strongly support the theory that J VI Himalia is indeed a C-class asteroid. The July data were taken on consecutive nights and, considering a rotational period of *either* 9.2 or 9.8 hours[1] for this moon of Jupiter, full spacial coverage of opposite sides was obtained.

On April 20, 1995, visible and near-infrared (0.49 - 0.95 µm) CCD reflectance spectra of J VI Himalia (dispersion = 7.92 Å/pixel) were taken at the Cerro Tololo Inter-American Observatory, Chile, using the 1.5-m telescope with a cassegrain spectrograph. These reflectance spectra were scaled to 1.0 around 0.56 µm and ratioed to solar analog stars SAO 159706 and SAO 120107 with little difference between the resulting spectra.

On July 18-19, 1996, visible and near-infrared (0.40 - 0.98 µm) CCD reflectance spectra of J VI Himalia (dispersion = 3.67 Å/pixel & 7.40 Å/pixel, respectively) were taken at University of Arizona's Steward Observatory at Kitt Peak using the 2.25-m telescope with a cassegrain spectrograph. These spectra were ratioed to 16 Cyg B on both nights and scaled to 1.0 around 0.56 µm. The July 19th data were not extinction corrected. J VI Himalia's airmass was 1.73 and its spectra were ratioed to spectra of solar analog star 16 Cyg B at an airmass of 1.49 on this night. The data display excellent correlation with the narrowband spectrophotometry of July 18th, 1996 and April 20, 1995 as well the ECAS photometry of Tholen and Zellner[2] taken on March 29, 1981. The ECAS photometry of J VI Himalia were converted such that the 0.550 µm reflectance (ν filter) is equal to 1.0. After a linear background continuum was removed, a 5-point smoothing was performed on all narrowband spectrophotometry.

Of Jupiter's eight known outer satellites, it is the inner four which is of concern to this paper: JVI Himalia, J VII Elara, J X Lysithea, and J XIII Leda. Their mean semimajor axis is a = 2.275 x 10^7 km.[1]. Four of the eight outer satellites travel in prograde orbit while the remaining four travel in retrograde orbit. The suggestion of satellite capture by nebula drag was first discussed in 1910 by See, then applied to Jupiter by Kuiper[3] who also suggested the breakup of captured parental bodies. This theory was revisted by Pollack *et al.* [4] when he performed a quantitative analysis to support the theory that the satellites were fragments of planetisimals lost and then recaptured by Jupiter. The gas-drag capture remains the most widely accepted of the theories and extends to suggest that the two groups of outer Jovian satellites were originally two captured asteroids subsequently fragmented when drawn into Jovian orbit. Radiometry at 20µm by Cruikshank[5] for Himalia and Elara first suggested a C-type material, later confirmed with polarization measurements by Degewij *et al.*[6]. Tholen and Zellner[2] gathered ECAS photometry of some of Jupiter's outer satellites and concluded that five of the moons, Himalia, Elara and Lysithea among these, appeared to be C-class asteroids. Hartmann[7] suggested that Jupiter resonances scattered C-type asteroids around the solar system allowing for C-type captures by Jupiter. Luu[1] concluded that J VI Himalia is a C-type asteroid and J X Lysithea is a D-type asteroid.

The narrowband spectrophotometry of both sides of J VI Himalia show no dramatic mineralogic differences from one another though the strength of an apparent 0.70 µm absorption feature tends to be stronger on the second night. This conclusion must be viewed with caution as an extinction correction was inacheivable for 7/19/96 data and the spectra have lower SNR. The absorption feature centered at 0.70 µm is evident in all three narrowband reflectance spectra and an absorption in this general area is seen in the ECAS photometry. As expected from previous studies, J VI Himalia's spectral shape appears to be that of a C-class asteroid. (See Figure 1.)

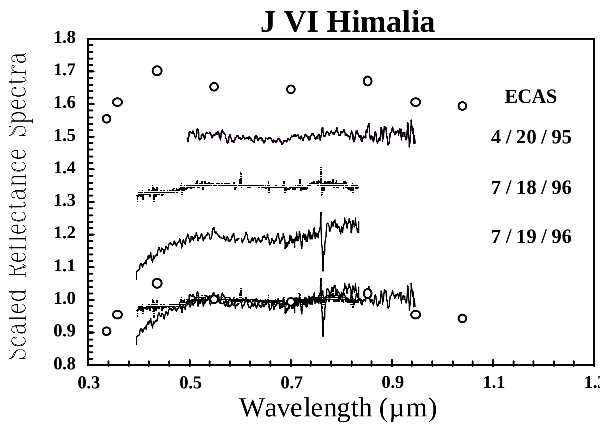

Figure 1. ECAS photometry and near-infrared reflectance spectra of J VI Himalia. ECAS photometry[2] was converted such that the 0.550 µm (ν filter) is equal to 1. Reflectance spectra were scaled to 1.0 around 0.56 µm and ratioed to SAO 159706 (04/20/95) and 16 Cyg B (07/18/96, 07/19/96). A 5-point smoothing of the reflectance spectra and removal of background linear continuum has been performed. Data have been overlain to show their good inter-spectral agreement as well as being individually offset for clearer visual inspection.

Features previously identified in visible and near-infrared reflectance spectra of C-class asteroids have included: (1) A 0.60 - 0.65 µm centered absorption feature generally associated with a 0.80 - 0.90 µm absorption feature and attributed to the presence of iron oxides[8,9]. (2) A 0.70 µm centered absorption feature associated with a 3.0 µm water of hydration absorption feature and attributed to phyllosilicates[9,10].

The 0.60 - 0.65 µm and 0.80 - 0.90 µm absorption features are attributed to $^6A_1 \rightarrow {}^4T_2(G)Fe^{3+}$ and $^6A_1 \rightarrow$

$^4T_1(G)Fe^{3+}$ charge transfer transitions in minerals such as goethite, hematite and jarosite, that are products of the aqueous alteration of anhydrous silicates. The 0.70 µm absorption feature is attributed to the $Fe^{2+} \rightarrow Fe^{3+}$ charge transfer transition in oxidized iron present in phyllosilicates. The associated 3.0 µm absorption feature is due to structural hydroxyl (OH) and interlayer and adsorbed H_2O.

J VI Himalia appears to have a 0.70 µm centered absorption feature although the center of 7/18/96 spectra's absorption feature is shifted to a slightly lower wavelength of 0.68 µm. While the 4/20/95 data and the 7/19/96 data have too much scatter to deny or confirm a 0.80 - 0.90 µm feature, the spectra of 7/18/96 suggest a downturn in this area. The expected 3.0 µm water of hydration feature is inexplicably absent in IR radiometery of J VI Himalia[11].

The spectra of J VI Himalia have been compared to two C-class asteroids with 0.70 µm features present in their spectra, 66 Maja and 187 Lamberta, to demonstrate the similarities between the reflectance spectra. (See Figure 2.) As C-class asteroids with the 0.70 µm absorption feature dominate the asteroid population at 2.6 - 3.5 A.U., this would suggest that J VI Himalia was formed in or near the main belt, was ejected and subsequently captured by Jupiter. If the theory that a parent asteroid had been captured and shattered into the four pieces now known J VI Himalia, J VII Elara, J X Lysithea, and J XIII Leda, then by extension, one would expect these other three moons of Jupiter to display similar mineralogical composition. ECAS data of Elara and Lysithea support this.

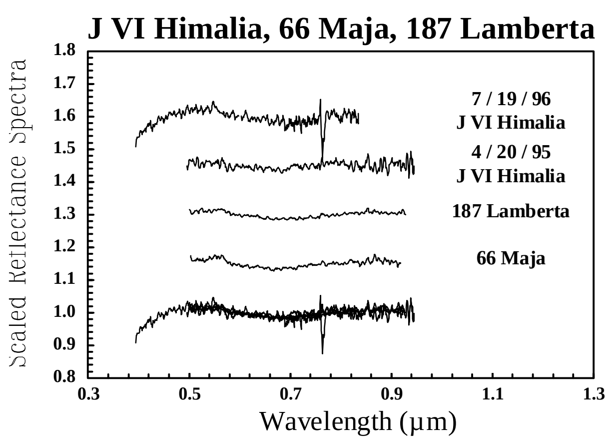

Figure 2. Near-infrared reflectance spectra of two C-class asteroids, 66 Maja and 187 Lamberta, which contain the 0.70 µm absorption feature, compared to two of the J VI Himalia spectra. Data have been overlain to show their good inter-spectral agreement as well as being individually offset for clear visual inspection.

References: [1]Luu, **Astr. J.** *Vol. 102, No. 3*, p.1213, 1991; [2]Tholen & Zellner, **Icarus** *58*, p.246, 1984; [3]Kuiper, **Proc. Nat. Acad. Sci.** *37*, p.1153, 1951; [4]Pollack, Burns, & Tauber, **Icarus** *37*, p.587; [5]Cruikshank, **Icarus** *30*, p.224, 1977; [6]Degewij, Cruikshank, & Hartmann, **Icarus** *44*, p.541, 1980; [7]Hartmann, **Icarus** *71*, p.57, 1987; [8]Jarvis, Vilas, & Gaffey, **LPSC XXIV**, p.715, 1993; [9]Vilas, Jarvis, Gaffey, **Icarus** *109*, p. 274, 1994; [10]Vilas, **Icarus** *111*, p.456, 1994; [11]Rivkin, A.S., personal communication.